Emerging Science of Nanotoxicology, with Günter Oberdörster

Ernie Hood

In 2004 Günter Oberdörster and colleagues published a seminal review on the emerging discipline of nanotoxicology, which was later selected as [*EHP*'s 2008 Paper of the Year]. In this podcast, Oberdörster tells why nanomaterials are so different from their larger chemical counterparts and describes the growing use of these materials in consumer products. Oberdörster is a professor in the Department of Environmental Medicine at the University of Rochester, New York, and director of the University of Rochester Ultrafine Particle Center.

AHEARN: It's *The Researcher's Perspective.* I'm Ashley Ahearn.

By manipulating matter on the atomic and molecular scale, scientists have entered the brave new world of nanotechnology. At the "nanoscale"—we're talking billionths of a meter here—materials can take on new properties. Manmade nanoparticles are being used in a variety of ways, from delivering cancer drugs in the body to improving the conduction of energy in electronic devices.

There are some lessons that the world of nanotech can learn from the world of toxicology, however. What happens when, say, the nanoparticles in a new brand of sunscreen make their way into our bodies? Or how about when nanoparticles are inhaled into deep lung tissue?

Dr. Günter Oberdörster is combining these two worlds. He's a professor in the Department of Environmental Medicine at the University of Rochester and director of the Ultrafine Particle Center.[1]

In this edition of *The Researcher's Perspective* science writer Ernie Hood talks with Dr. Oberdörster about the emerging field of nanotoxicology.

HOOD: Dr. Oberdörster, what is it about the nanoparticles that give them such different properties from their larger chemical counterparts? And by the same token, why do they appear to be more biologically active?

OBERDORSTER: Yeah, there are several things. One is, one major route of uptake is by inhalation of airborne nanoparticles. Of course in addition there are uptake routes—oral, into the GI tract, or the dermal route—which I think are not as prominent as inhalation. And here is the first difference to larger particles—these particles below 100 nanometers in size, when they are airborne, occurring as aerosols, behave differently insofar as they are depositing throughout the respiratory tract by diffusion, rather than the bigger particles by impaction and by sedimentation. And the important fact is that all regions of the respiratory tract have different preferential sizes of nanoparticles, which deposit there to the highest degree. That's the first part.

And then secondly, once these nanoparticles are depositing, they behave different from larger particles in that there's a greater likelihood for them not to be seen by defenses in the body and will be taken up by epithelial cells. And then some of them will also be translocating across the epithelial layer into the blood circulation. In other parts, like in the upper respiratory tract, they can be taken up by sensory nerves, such as the olfactory nerve, and translocated to the central nervous system.

These features of nanoparticles to be able to move to different organs across membranes are being used in the development of drugs to be delivered by nanoparticles to site-specific diseases. For example, nanoparticles loaded with anticancer drugs and covered, coated, with a homing protein for specific tumors in experimental animals has been shown to successfully fight cancer in those animals.

HOOD: So there is an upside and a downside to the permeability of these particles…

OBERDORSTER: Yeah, well, that's exactly right. I mean, on the one hand, it's a desirable feature when we talk about therapeutic or even diagnostic applications using nanomaterials. On the other hand, nanomaterials, nanoparticles that are being used in consumer products, depending on what it is, they may do and will do the same thing and translocate from the portal of entry to specific organs, which depending on what the chemistry of the particle is, specifically surface chemistry, could cause some adverse effects. Now, we have to be careful, though, to associate with any nanoparticle a serious risk, because most—in my view, at least—most of the nanoparticles that we might be exposed to or will be exposed to will not cause any serious adverse effects, because the doses that we receive are very small.

HOOD: Now, it has long been recognized that the development of the technology has been driving well ahead of the research into health and safety issues. Do you think that that imbalance has been corrected enough at this point for the technology to be adopted on a widespread basis? Or do we still need to proceed with caution?

OBERDORSTER: No, first of all, I would not suggest any moratorium, as I think some groups have advertised to place a moratorium on the development of nanotechnology, and I think that would be wrong. On the contrary, we should certainly move ahead and find out, develop the beneficial side of nanotechnology as fast as possible. But at the same time, we need to be very, very careful, and try to avoid human exposure. Use protective equipment—respiratory protective equipment, personal protective equipment—and avoid any contamination in skin, as well as inhalation for sure, but also oral uptake of those materials. And again, we have no specific cases yet, which is of course very fortunate, of any adverse effect, but we need to be very vigilant and observe all necessary precautions when proceeding with work with nanoparticles.

Now, the issue with respect to consumer products: there are many, many hundreds of consumer products using nanotechnology on the market already, and most of these products, they are such that the nanomaterials, nanoparticles, are embedded in a matrix. So I don't see any danger of an exposure if the particles, for example, are nanomaterials embedded in, let's say, sporting goods like tennis rackets or even skis, which I have recently seen in Japan.

A different issue is if nano-enabled products come on the market that are to be used as a spray and to keep surfaces clean and self-cleaning materials and such. There I would be extremely careful and certainly not advertise to use it at all. That is, in my view then, a case where that would be going too far to be sold to the public for consumers' use.

HOOD: What direction are you planning to take with your research in this area?

OBERDORSTER: There is another important issue, and that has to do with identifying first of all the hazard of nanoparticles and eventually also their associated risk. And of course the ultimate study would always be to do animal studies. Now, given the multitude of materials that are coming on the market, it's impossible for several reasons, among them also ethical reasons, to do all of this in animal studies. So what we and also other laboratories are working on is to develop simple assays to look at the results in those studies that are predictive for what we might be seeing *in vivo*, such that nanomaterials can be tested easily, and with high predictive power and value, to let industrial manufacturers know as to whether it's worthwhile to pursue that material further, or not to do so because it's just too hazardous and, even with low exposure levels, might pose a significant risk.

AHEARN: That was Dr. Günter Oberdörster talking with science writer Ernie Hood. Dr. Oberdörster is a professor in the Department of Environmental Medicine at the University of Rochester and director of the Ultrafine Particle Center.

And that's *The Researcher's Perspective*. I'm Ashley Ahearn. Thanks for downloading!

Reference

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[1] Dr. Oberdörster's review article "Nanotoxicology: An Emerging Discipline Evolving from Studies of Ultrafine Particles" [Environ Health Perspect 113(7):823–839 (2005)] was selected as an *EHP* Paper of the Year.

Ernie Hood is a science writer, editor, and podcast producer in Hillsborough, North Carolina. He also produces and hosts the weekly science radio show *Radio in Vivo*.